Turkish Journal of Unmanned Aerial Vehicles

Türkiye İnsansız Hava Araçları Dergisi

https://dergipark.org.tr/tr/pub/tiha

e-ISSN 2687-6094

Using of Hybrid Data Acquisition Technique for Cultural Heritage a Case Study of Pompeiopolis

Seda Nur Gamze Hamal*[1], Binnaz Sarı [1], Ali Ulvi [1]

[1] *Mersin University, Institute of Science, Remote Sensing and Geographical Information Systems, Mersin, Turkey*

Keywords
TLS
UAV
Photogrammetry
CrP
Hybrid

ABSTRACT

Various studies have been carried out on the documentation of cultural heritage with different methods. The correct data collection method is as important as the selection of the method to be used in the studies. Documentation studies focus on saving time and cost rather than data collection methods. However, obtaining accurate and complete data increases the accuracy of the documentation work. At this point, image-based documentation studies such as photogrammetry provide important contributions to operators. Although a single data collection tool is preferred in most of the studies conducted with the photogrammetry method, it is necessary to obtain images from different locations (ground and air) for accurate and complete data. Recently, the term Unmanned Aerial Vehicles (UAV) photogrammetry has emerged with the use of UAV in documentation studies. In this way, a complete model is created in the documentation studies to be performed by collecting data from both the ground and the air. In this study, three different data collection methods were used for documentation. Hybrid data collection approach, Terrestrial Laser Scanning (TLS) and Close-range Photogrammetry (CrP), and UAV photogrammetry techniques are selected and presented. Finally, three-dimensional (3D) data of Soli-Pompeiopolis were created by combining these point clouds.

Kültürel Miras için Hibrit Veri Toplama Tekniğinin Kullanılması: Pompeiopolis Örneği

Anahtar Kelimeler
YLT
İHA
Fotogrametri
Yersel Fotogrametri
Hibrit

ÖZET

Kültürel mirasın farklı yöntemlerle belgelenmesi konusunda çeşitli çalışmalar yapılmıştır. Çalışmalarda kullanılacak yöntemin seçimi kadar doğru veri toplama yöntemi de önemlidir. Dokümantasyon çalışmaları, veri toplama yönteminden çok, zamandan ve maliyetten tasarruf etmeye odaklanır. Ancak, doğru ve eksiksiz verilerin elde edilmesi dokümantasyon çalışmasının doğruluğunu artıracaktır. Bu noktada fotogrametri gibi görüntü temelli dokümantasyon çalışmaları operatörlere önemli katkılar sağlamaktadır. Fotogrametri yöntemi ile yapılan çalışmaların çoğunda tek bir veri toplama aracı tercih edilmekle birlikte, doğru ve eksiksiz veri için farklı lokasyonlardan (yer ve hava) görüntü elde edilmesi gerekmiştir. Son zamanlarda İnsansız Hava Araçlarının (İHA) dokümantasyon çalışmalarında kullanılmasıyla İHA fotogrametrisi terimi ortaya çıkmıştır. Böylelikle hem yerden hem de havadan veriler toplanarak yapılacak dokümantasyon çalışmalarında eksiksiz bir model oluşturulur. Bu çalışmada dokümantasyon için üç farklı veri toplama yöntemi kullanılmıştır. Hibrit veri toplama yaklaşımı, Yersel Lazer Tarama (YLT), Yersel Fotogrametrisi ve (İHA) fotogrametrisi teknikleri seçilerek sunulmuştur. Son olarak, bu nokta bulutları birleştirilerek Soli-Pompeiopolis'in üç boyutlu (3B) verileri oluşturulmuştur.

***Sorumlu Yazar (*Corresponding Author)**

*(sedanurgamzehamal@gmail.com) ORCID ID 0000-0002-1050-3088
(binnaz452@gmail.com) ORCID ID 0000-0002-8240-9680
(aliulvi@mersin.edu.tr) ORCID ID 0000-0003-3005-8011

Cite this article *(APA);*

Hamal S N G, Sarı B & Ulvi A (2020). Using of Hybrid Data Acquisition Technique for Cultural Heritage a Case Study of Pompeiopolis. Turkish Journal of Unmanned Aerial Vehicles, 2(2), 55-60

Araştırma Makalesi (Research Article) / DOI: XXXXXXXXXXXX

Received: 18/11/2020; Accepted: 12/12/2020

1. INTRODUCTION

Cultural structures are damaged over time due to natural or unnatural reasons. Besides, archaeological sites are also affected by this situation, as well as the destruction of the structure. The restoration, restitution, and excavation works of the destructions that have occurred contribute to the correct research and transfer of the artifacts or archaeological sites. The first step in the work to be done in an artifact or archaeological site is documentation studies (Unger et al., 2014; Rinaudo et al., 2012; Alshawabkeh et al., 2020; Şenol et al., 2020).

Various studies are carried out on documentation studies using different methods (Aragon et al., 2018; Wilson et al., 2018). Ulvi et al. (2020) classified the documentation of cultural heritage into two titles as traditional and advanced methods. They included TLS, CrP, and UAV photogrammetry, which also includes the subject of this study, in advanced methods (Şenol et al., 2017; Messaoudi et al., 2018; Xiao et al., 2018).

The photogrammetric method is one of the most often used techniques in documentation studies. The photogrammetric method is more efficient than traditional methods, 25 times more advantageous in terms of graphics, and 10 times more accurate in terms of accuracy (Şanlığolu, 2013; Yakar et al., 2016; Ulvi & Yiğit, 2019; Şenol & Kaya, 2019; Ulvi et al., 2019; Alptekin & Yakar, 2020). In addition, Yakar et. al 2015; Ulukavak et al., 2019) stated that the photogrammetry technique saves time and cost compared to traditional documentation techniques. Especially in documentation studies, it is desired to save time and cost in collecting data (Çelik et Al., 2020; Yakar et al., 2021). However, while trying to save cost and time, choosing the wrong data collection method can push the operator to collect incomplete data. Collect complete data is an important factor in method selection. For this reason, several data collection methods should be used to collect all data belonging to the study area. Therefore, in the study, data were collected using TLS, CrP, and UAV photogrammetry methods, which are among the modern methods (Assali et al., 2014; Aicardi et al., 2016; Liang et al., 2018).

The use of a single method in modeling complex structures, especially in the photogrammetry technique, in the documentation of cultural heritage does not allow accurate and complete documentation (Yiğit et al., 2020). Because, with terrestrial systems (TLS and CrP), the data of the bottom part of the structure can be taken, but the top of the structure cannot be collected (Ulvi & Yiğit, 2020a). The data deficiency arising from this situation can be overcome by changing the location where the device is installed or by using another data collection tool to collect the data of the upper fronts. UAVs, which have been used by many disciplines in recent years, have been integrated into this area and this problem has been overcome.

In this study, TLS, CrP, and UAV photogrammetry techniques, which are among the modern data collection and documentation techniques, were used. The hybrid data collection deal is presented by selecting laser scanning (TLS) (Figure2) and Close-range photogrammetry (CrP) (Figure 3) and UAV photogrammetry techniques (Figure 4). An accurate and dense set of 3D points belonging to all facets of the structure was acquired with hybrid data collection techniques. The TLS, CrP, and UAV photogrammetry techniques used in the study were processed separately and the accuracy of 0,4-1,1-1,3 cm was calculated respectively. Finally, a three-dimensional (3D) data of Soli-Pompeiopolis were created by combining these point clouds.

2. METHOD

TLS method, CrP, and UAV photogrammetry are frequently used in 3D modeling of historical and cultural sites (Beraldin, 2004; Gašparović & Malarić, 2012; Jo & Kim 2017; Kaya et al., 2019). However, in some areas, it becomes necessary to use both laser scanning, CrP, and UAV photogrammetry, both the height and the shape of the structures and areas (Chiabrando et al., 2017; Ulvi & Yiğit, 2020b; Yiğit & Uysal, 2020). Because the high columns in the historical area caused laser beams to be invisible. The existence of archaeological excavations in some parts of the region made it difficult to install a laser scanning device. Thus, CrP and UAV photogrammetry method is used in places where laser beams cannot be seen. In this study, the TLS method, CrP, and UAV photogrammetry were used in a hybrid the way that.

2.1. Study Area

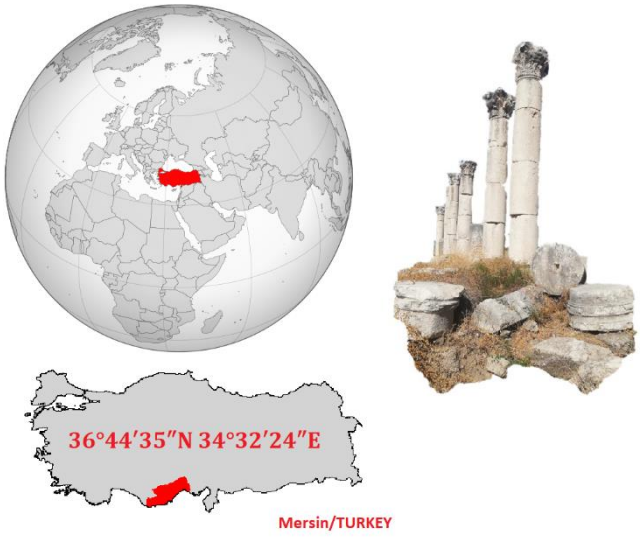

Figure 1. Study Area

Soli Pompeopolis located in Mersin / Turkey (Figure 1), is one of the most important ruins of the province where it is located. It is a large site with an ancient harbor (URL-1). According to the archaeological excavations started in 1999: BC. It has been among the important port cities of the Eastern Mediterranean since 2000. There are 49 columns on the site and the columns are in a complex structure with Corinthian type capitals (URL-2).

2.2. Data Acquisition, Field-Work, and Office-Work

In the documentation made in the study, data were collected using TLS, CrP, and UAV photogrammetry techniques. For TLS, CrP, and UAV, respectively; Faro FocusS 350 - Nikon D300 - Anafi Parrot devices are used.

Figure 2: Terrestrial Laser Scanning (TLS) technique

Scans were made at 49 different station points determined in the study area. The number and location of the station points have been determined in a way that the area to be scanned can see one or more areas.

Figure 3: UAV Photogrammetry

Figure 4: CrP Photogrammetry

Overlapping photographs were taken for CrP and UAV photogrammetry. For CrP 326 image data were collected for 78 UAV. Photo data were collected manually for CrP and automatically for UAV. Also, with Total-stations, target, and characteristic details were measured to transfer the result products created from different data collection methods both for registration and to the same scale and coordinate system.

In the process of data processing, firstly, pre-processing was performed for all data collection techniques. The data taken from the TLS method were transferred to the JRC 3D Reconstructor software.

After the created data, a point cloud was produced by geo-referencing. Data from CrP and UAV were also combined in the Contex Capture software. The CrP, UAV photogrammetry and TLS techniques used in the study were processed separately and the accuracy of 1,3-1,1-0,4 cm was calculated respectively. The data obtained from CrP and UAV photogrammetry method and the data obtained from TLS were combined in the same coordinate system in the JRC 3D Reconstructor software in a hybrid way. The methods used in the study and the chart of work-flow are given in Figure 5.

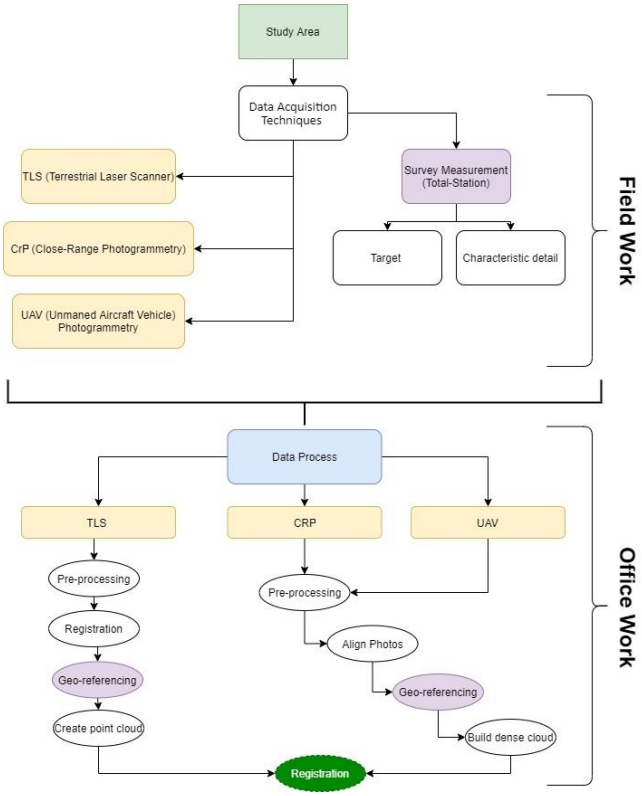

Figure 5: Workflow Chart

The mean error of the combined data from these techniques was calculated as ±0.97 cm. Finally, a 3D model of Soli-Pompeiopolis was created by combining these point clouds.

Created point cloud and mesh model are given in Figure 6 and Figure 7.

Figure 6: The resulting dense point clouds.

Figure 7: The resulting mesh model

3. DISCUSSION AND CONCLUSION

TLS, CrP, and UAV photogrammetry often have been used. By using these techniques together, complete data of the study area can be collected. In the study, while evaluating the data obtained from all systems (TLS, UAV, and CrP), the advantages and disadvantages of the systems were also examined. In this study; Fast, high quality and resolution data can be collected at close-range with the TLS method. However, this method has two disadvantages due to its cost and data collection. Although the CrP method saves time and is a low-cost data collection method, it has a disadvantage due to its data collection and not being able to be used effectively in large areas.

Firstly, it has yielded quite successful results in 3D modeling in all systems. However, with the UAV system, the data required for 3D modeling can be obtained faster and the data are processed faster. UAV photogrammetry has an advantage in terms of aerial data collection and cost, but it is affected by weather conditions and is not used in every area (prohibited area). In the scanning process with the lidar scanner, there were some deficiencies in the joints of the columns and the upper parts of the structures due to the measurement principle of the TLS system. In such cases, it is necessary to install the TLS system in line with the object to be scanned as possible or a little higher. Therefore, the working area was scanned using the maximum viewing angle that can be taken from the ground. On the other hand, the missing parts of the TLS system were successfully measured in this system, provided that the UAV system was scanned from the top and taking an oblique image on the lateral surfaces. However, CrP technique was used to obtain detailed lateral surfaces of the remains. For this reason, the hybrid method should be used as these methods are insufficient. Thus, a complete document belonging to the study area has been created. The historical work of this document; It is anticipated that it will contribute to the transmission, preservation, documentation, and management of future generations.

REFERENCES

Aicardi I, Dabove P, Lingua A M & Piras M (2016). Integration between TLS and UAV photogrammetry techniques for forestry applications. *iForest-Biogeosciences and Forestry*, 10 (1), 41.

Alptekin A & Yakar M (2020). Mersin Akyar Falezi'nin 3B modeli. *Türkiye Lidar Dergisi*, 2 (1), 5-9.

Alshawabkeh Y, El-Khalili M, Almasri E, Bala'awi F & Al-Massarweh A (2020). Heritage documentation using laser scanner and photogrammetry. The case study of Qasr Al-Abidit, Jordan. *Digital Applications in Archaeology and Cultural Heritage*, 16, e00133.

Aragón E, Munar S, Rodríguez J & Yamafune K (2018). Underwater photogrammetric monitoring techniques for mid-depth shipwrecks. *Journal of Cultural Heritage*, 34, 255-260.

Assali P, Grussenmeyer P, Villemin T, Pollet N & Viguier F (2014). Surveying and modeling of rock discontinuities by terrestrial laser scanning and photogrammetry: Semi-automatic approaches for linear outcrop inspection. *J. Struct. Geol.*, 66, 102–114.

Beraldin J A (2004). Integration of Laser Scanning and Close-Range Photogrammetry—The last decade and beyond. In Proceedings of the International Archives of Photogrammetry and Remote Sensing, XXXV–B4, Istanbul, Turkey, 12–23 July 2004; 12–23.

Çelik M, Yakar İ, Hamal S N G, Oğuz G M & Kanun E (2020). Sfm Tekniği ile Oluşturulan 3B Modellerin Kültürel Mirasın Belgelenmesi Çalışmalarında Kullanılması: Gözne Kalesi Örneği. *Türkiye İnsansız Hava Araçları Dergisi*, 2 (1), 22-27.

Chiabrando F, Spanò A, Sammartano G & Teppati Losè L (2017). UAV oblique photogrammetry and lidar data acquisition for 3D documentation of the Hercules Fountain. *Virtual Archaeology Review*, 8 (16), 83-96.

Gašparović M & Malarić I (2012). Increase of readability and accuracy of 3D models using fusion of close range photogrammetry and laser scanning. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 39, B5.

Jo Y H & Kim J Y (2017). Three-Dimensional Digital Documentation of Heritage Sites Using Terrestrial Laser Scanning and Unmanned Aerial Vehicle Photogrammetry. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 42 (2/W5).

Kaya Y, Şenol H İ, Memduhoğlu A, Akça Ş, Ulukavak M & Polat N (2019). Hacim Hesaplarında İHA Kullanımı: Osmanbey Kampüsü Örneği. *Türkiye Fotogrametri Dergisi*, 1 (1), 7-10.

Liang H, Li W, Lai S, Zhu L, Jiang W & Zhang Q (2018). The integration of terrestrial laser scanning and terrestrial and unmanned aerial vehicle digital photogrammetry for the documentation of Chinese classical gardens–A case study of Huanxiu Shanzhuang, Suzhou, China. *Journal of Cultural Heritage*, 33, 222-230.

Messaoudi T, Véron P, Halin G & De Luca L (2018). An ontological model for the reality-based 3D annotation of heritage building conservation state. *Journal of Cultural Heritage*, 29, 100-112.

Rinaudo F, Chiabrando F, Lingua A & Spanò A (2012). Archaeological site monitoring: UAV photogrammetry can be an answer. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 39 (B5), 583-588.

Şanlıoğlu İ, Zeybek M & Karauğuz G (2013). Photogrammetric Survey and 3D Modeling of Ivriz Rock Relief in Late Hittite Er. *Mediterranean Arhaeology and Archaeometry*, 13 (2).

Şenol H & Kaya Y (2019). İnternet Tabanlı Veri Kullanımıyla Yerleşim Alanlarının Modellenmesi: Çiftlikköy Kampüsü Örneği. *Türkiye Fotogrametri Dergisi*, 1 (1), 11-16.

Şenol H I, Erdogan S, Onal M, Ulukavak M, Memduhoglu A, Mutlu S & Yilmaz M (2017). 3D Modeling of A Bazaar In Ancient Harran City Using Laser Scanning Technique. *International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences*, 42.

Şenol H I, Memduhoğlu A & Ulukavak M (2020). Multi instrumental documentation and 3D modelling of an archaeological site: a case study in Kizilkoyun Necropolis Area. *Dicle Üniversitesi Mühendislik Fakültesi Mühendislik Dergisi*, 11 (3), 1241-1250.

Ulukavak M, Memduhoğlu A, Şenol H İ & Polat N (2019). The use of UAV and photogrammetry in digital documentation. Mersin Photogrammetry Journal, 1(1), 17-22.

Ulvi A & Yiğit A (2019). Kültürel Mirasın Dijital Dokümantasyonu: Taşkent Sultan Çeşmesinin Fotogrametrik Teknikler Kullanarak 3B Modelinin Yapılması. Türkiye Fotogrametri Dergisi, 1 (1), 1-6.

Ulvi A, Yakar M, Yiğit A Y & Kaya Y (2020) İHA ve Yersel Fotogrametrik Teknikler Kullanarak Aksaray Kızıl Kilise'nin 3 Boyutlu Nokta Bulutu ve Modelinin Üretilmesi, *Geomatik Dergisi*, 5 (1), 19-26.

Ulvi A & Yiğit A Y (2020a). 3D Modelling of Kayseri Tekgoz Bridge. *Mersin Photogrammetry Journal*, 2 (1), 29-32.

Ulvi A & Yiğit A Y (2020b). 3D study of modelling and animation of Kayseri Gülük Mosque. *Mersin Photogrammetry Journal*, 2 (2), 33-37.

Ulvi A, Yakar M, Yiğit A Y & Kaya Y (2019). The Use of Photogrammetric Techniques in Documenting Cultural Heritage: The Example of Aksaray Selime Sultan Tomb. *Universal Journal of Engineering Science*, 7 (3), 64-73.

Unger J, Reich M & Heipke C (2014). UAV-based photogrammetry: monitoring of a building zone. International Archives of the Photogrammetry, *Remote Sensing and Spatial Information Sciences-ISPRS Archives,* 40 (5), 601-606.

Wilson L, Rawlinson A, Frost A & Hepher J (2018). 3D digital documentation for disaster management in historic buildings: applications following fire damage at the Mackintosh building, The Glasgow School of Art. *Journal of Cultural Heritage*, 31, 24-32.

Xiao W, Mills J, Guidi G, Rodríguez-Gonzálvez P, Barsanti S G, González-Aguilera D (2018) Geoinformatics for the conservation and promotion of cultural heritage in support of the UN Sustainable Development Goals. *ISPRS J. Photogramm. Remote. Sens*., 142, 389–406.

Yakar İ, Çelik M, Hamal S & Bilgi S (2021). Kültürel Mirasın Dokümantasyonu Çalışmalarında Farklı Yazılımların Karşılaştırılması: Dikilitaş (Theodosius Obeliski) Örneği. *Geomatik Dergisi*, 6 (3), 217-226.

Yakar M, Kabadayı A, Yiğit A Y, Çıkıkcı K, Kaya Y & Catin S S (2016). Emir Saltuk Kümbeti Fotogrametrik Rölöve Çalişmasi ve 3 Boyutlu Modellenmesi. Geomatik, 1 (1), 14-18.

Yakar M, Orhan O, Ulvi A, Yiğit A Y & Yüzer M M (2015). Sahip Ata Külliyesi Rölöve Örneği. TMMOB Harita ve Kadastro Mühendisleri Odası, 10.

Yiğit A Y, Kaya & Kabadayı A (2020). Comparison of Documenting Cultural Artifacts with the 3D Model in Different Software. *Mersin Photogrammetry Journal*, 2 (2), 51-58.

Yiğit A Y & Uysal M (2020). Automatic Road Detection From Orthophoto Images. *Mersin Photogrammetry Journal*, 2 (1), 10-17.

Digital References

URL-1http://www.solipompeiopolis.com/icerik/1/turkce.html

URL-2 http://www.soli-pompeiopolis.com/icerik/19/2010-kazilari.html